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A knowledge exchange system: Putting innovation to work

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Abstract

Effective and efficient application of new knowledge and technology in Canada's forest sector continues to challenge both government and industry. This impedes the development of government policy and advancement in private sector diversification and productivity growth. This paper outlines a knowledge exchange system by which researchers and customers in government and industry can achieve desired business outcomes through the optimal development and application of innovative approaches. The system integrates three major functions—knowledge generation, knowledge exchange, and knowledge application. The importance of extension professionals is highlighted as a critical link in helping to ensure that new knowledge and innovative technologies are put into practice. Nine knowledge system elements are introduced and the role of each in bridging the research-to-operations gap is described.

KEYWORDS: *knowledge exchange, forest sector, innovation, research-to-operations continuum, extension.*

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Introduction

Sustaining the world's renewable forest resources as well as accommodating increased social and economic demands from those resources, requires an innovative, knowledge-based forest sector. Heightened global interest in forest sustainability over the last decade has increased pressure on the forestry sector to demonstrate that the best available information is used in decisions related to forest production and land management. Investment in the development of sound, scientific information is currently stimulated by: concerns about the adequacy of environmental policies; market uncertainties and globalization; the movement towards results-based policy regulation; technological advances to ensure effective, efficient use of resources; an increased awareness of the value of maintaining diverse ecological conditions; and concerns about climate change.

Adopting and using the knowledge that arises from investments in science is important in applying advancements (innovations); however, how can one ensure that the new knowledge generated through research will be expressed in policy and (or) practice? The answer lies in the development and implementation of a systems approach that integrates the functions and activities of a knowledge exchange system with individuals who have both the expertise and the responsibility to put new knowledge into mainstream business (i.e., policy development, resource management planning, or value-added product development). If gaps in the system lead to dysfunctional knowledge exchange, then the benefits of research are not realized and the consequential costs of complacency can be devastating.

This paper introduces a knowledge exchange system that will help ensure innovative solutions for advancing Canada's forest sector are developed and applied in light of social, economic, and environmental values.

Background

Universities, government, industry, and private sector research institutes in Canada are recognized for their capacity to develop and contribute science and technology information that is relevant to sustainable resource management. However, this knowledge capital does not return a benefit to society unless those that need the knowledge (the "customers") can acquire and use it. It is the acceptance, application, and evaluation of knowledge that fosters innovation in achieving a knowledge-based, sustainable forest sector.

A knowledge exchange system enables individuals and corporations to generate, exchange, and apply knowledge capital to improve their decision-making ability.

A knowledge exchange system enables individuals and corporations to generate, exchange, and apply knowledge capital to improve their decision-making ability. Although the concept seems simple, connecting these three attributes is not. The knowledge generation and application communities typically work in disconnected environments. In addition, cultural, institutional, and capacity barriers exist that pre-empt the acceptance and use of innovations (Anderson 1997; Hollstedt and Swift 1999). These barriers are exacerbated by a rewards system that values peer-reviewed publications over extension products or services (DeYoe 1998; Graves 2000). A knowledge exchange system, which integrates knowledge generation with its application, would improve the return on research investment by helping put new knowledge into practice.

Knowledge Exchange System

Putting knowledge to work is more easily said than done. Critical functions must be considered in the continuum from basic research to adoption and use of new knowledge or technology and its evaluation in practice. Done correctly, this process can lead to additional benefits from secondary innovations (Figure 1). Nine knowledge system elements are identified and discussed below.

Understanding Extension

Extension is represented by a group of "knowledge exchange" activities that reside along the research-to-operations continuum between research (i.e., "knowledge generation") and operations (i.e., "knowledge application") (Figure 2). The term "knowledge exchange" reflects the sharing of information and ideas among project participants representing different science disciplines and institutional sectors (Miller and Morris 1999). Knowledge exchange starts at the problem-definition phase and continues through to evaluation and feedback on the use and utility of the new knowledge.

FIGURE 1. The research-to-operations continuum.

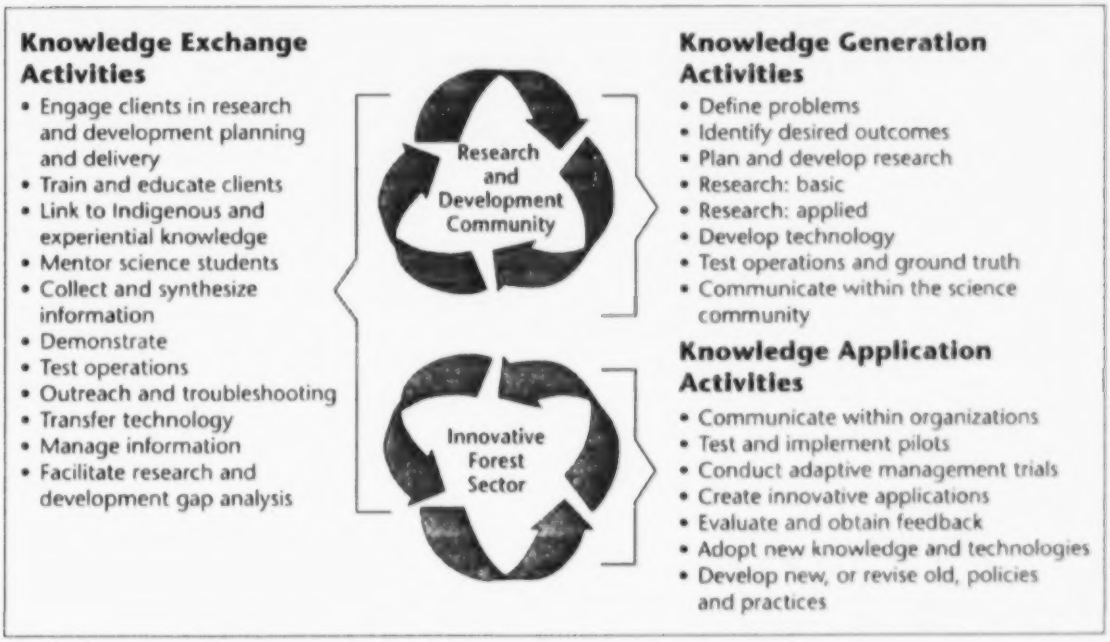
Knowledge Exchange Activities
• Engage clients in research and development planning and delivery
• Train and educate clients
• Link to Indigenous and experiential knowledge
• Mentor science students
• Collect and synthesize information
• Demonstrate
• Test operations
• Outreach and troubleshooting
• Transfer technology
• Manage information
• Facilitate research and development gap analysis
Research and Development Community
Innovative Forest Sector
Knowledge Generation Activities
• Define problems
• Identify desired outcomes
• Plan and develop research
• Research: basic
• Research: applied
• Develop technology
• Test operations and ground truth
• Communicate within the science community
Knowledge Application Activities
• Communicate within organizations
• Test and implement pilots
• Conduct adaptive management trials
• Create innovative applications
• Evaluate and obtain feedback
• Adopt new knowledge and technologies
• Develop new, or revise old, policies and practices

FIGURE 2. Important activities in the knowledge exchange system.

Although any new idea will likely involve only a few crucial innovators, the project team should include all individuals who will be responsible for important functions along the continuum. This ensures that, at the outset, desired customer outcomes are incorporated into the experimental design, analysis, and extension plan. If this does not occur, then it is highly likely that a research result or product will be inconsistent with the customer's expectations. This could result in the customer refusing the product and or taking their business elsewhere.

Respecting Different "Real Worlds"!

Customers often tell researchers that "you need to understand the real world"; however, a similar comment could just as easily originate from the researcher. The worlds within which different institutional sectors reside are very different (Figure 3). Since the attributes of a good researcher and a good resource professional are not necessarily the same, it is not surprising that communication gaps may exist between what is important and of value to individuals from these different, but "real," worlds. Attempting to "push" these worlds together, although possible, is fraught with pitfalls. Since the researcher's plan must align with the resource professional's needs, the challenge is to bridge such gaps. A more fundamental point is one of professional respect—the willingness to work together to ensure that new knowledge is translated into a useful product. Respecting one another's real worlds is the first step in achieving this objective and developing a positive relationship.

Building Extension Culture and Capacity

Extension professionals who fill the gap(s) between research and operations must exhibit a strong customer service ethic (Figure 4). The scope of their work is diverse; it transcends multiple scales in space and time, and spans organizational sectors. Extension professionals are generalists, working with one foot in science and the other in education. They often have experience in policy, planning, or field operations, and belong to government, university, industry, or community groups.

Filling the gap(s) in the research-to-operations continuum by using one or more extension professionals is an efficient, effective approach. The extension of existing research results to decision makers, either directly from the researcher or with the help of an extension professional, ensures that the benefit of the research investment is achieved. For example, in British Columbia, the work year of one FORREX extension specialist resulted in over $10 million in benefits through improved monitoring and silviculture prescription practices. This is compared to an annual provincial research investment in that same year of $20 million. To realize ongoing benefits from research investments, resource allocation decisions must create organizational functions that are more strongly customer-driven; this, in turn, aligns science activities with corporate direction and business objectives (Roussel *et al.* 1991).

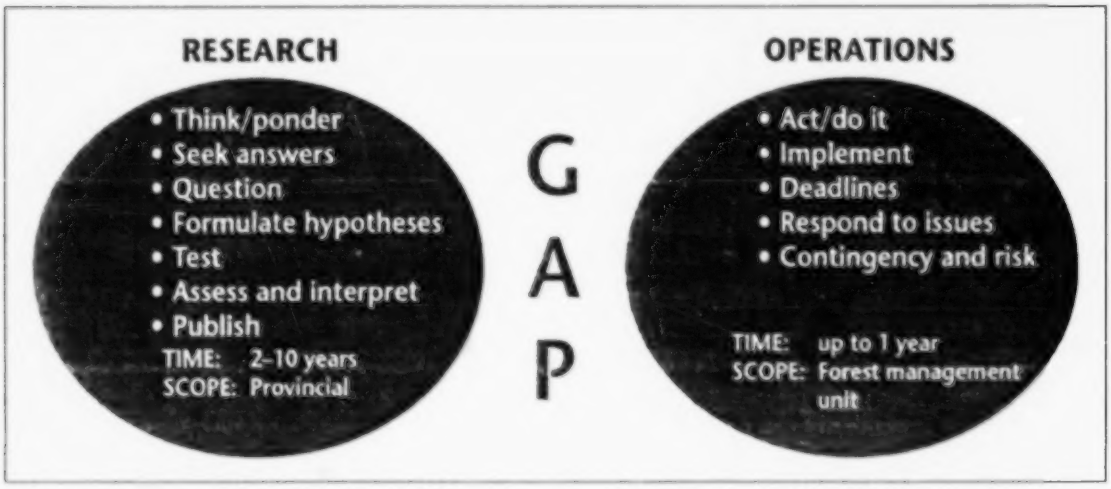

FIGURE 3. The different "real" worlds of research and operations professionals (from DeYoe 1998).

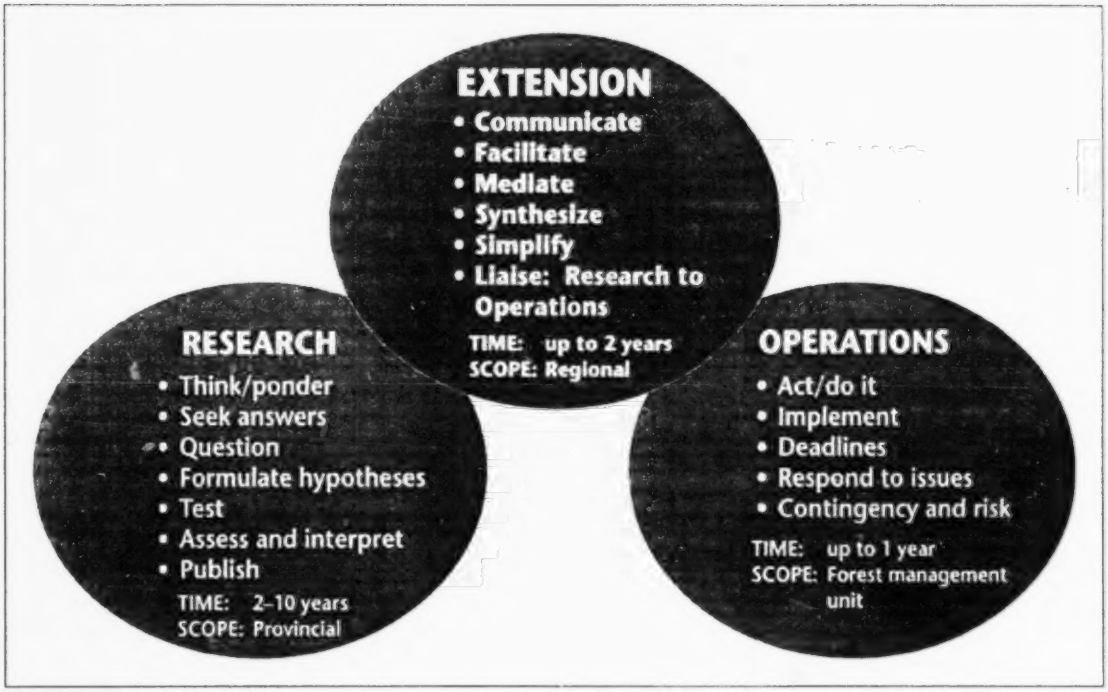

FIGURE 4. The role of extension in filling the knowledge gap.

This approach is not an inherent part of university systems in Canada. However, current funding institutions that require the matching of federal research dollars by client organizations obligate university-based programs to provide products and services beyond traditional peer-reviewed journal articles. For example, if a specific customer makes a request and provides funding to supplement federal or provincial research grants, then the university researcher should ascertain which products and services will best assist the customer to adopt and use the new knowledge. Some institutions and programs are creating extension models to meet the growing demand for relevant extension products and services (DeYoe 1998). The Forest Engineering Research Institute of Canada, FORINTEK Canada Corp., PAPRICAN, and FORREX are examples of Canadian associations whose performance is motivated by client expectations and needs. These models:

- address the institutional, financial, and intra-organizational barriers in the innovation community by hiring professionals responsible for extension-based functions and activities; and
- emphasize collaboration among players in the knowledge exchange system.

Building Relationships and Trust

Effective knowledge exchange is based on relationships and trust. Extension professionals are selected based partly on their proven abilities to develop and maintain strong relationships with their clientele and colleagues. Developing trust is an important focus for extension professionals, who serve as facilitators, synthesizers, translators, problem-solvers, or mediators to bring individuals together (Figure 4). Whether an extension professional is utilized or not, best practice requires a good relationship between the researcher and the customer, and an institutional environment that provides leadership, resources, and management to develop and maintain that relationship. Extension professionals can provide valuable services in establishing the trust that provides the foundation for a strong relationship.

Capturing Innovation: Engaging the Players

Discontinuous innovations, which can achieve significant advances, arise most often through the interaction of individuals from different science disciplines and institutional sectors (Miller and Morris 1999). These

innovations reflect convergent and collaborative thinking and discussions about desired outcomes, as well as how the associated products or services can best be addressed by research. It is important that the researcher and customer connect at the outset of these discussions so that the needs of the customer are explicitly translated into the experimental design and analysis strategy of the researcher and the desired outcome is defined. This allows the researcher to be creative in developing an innovative solution for the customer (or "developmental" innovation). Equally important is the use and evaluation of the new knowledge by a customer. This facilitates inclusion of the new knowledge into mainstream business and fosters the development of secondary improvements (or "application" innovation). These reflect the creativity of customers in improving their own business solutions.

Both types of innovations arise through engaging a diversity of people in the process of planning and delivering the research to achieve the desired outcome(s), and are a primary focus for the extension professional.

Knowing Your Customer!

Understanding your customer—why they need information and how they would use it—is critical to effective knowledge exchange (Hollstedt *et al.* 2004). The extension professional helps the customer and the researcher to find a common ground from which they can listen to, appreciate, and understand one another. Another important responsibility of the extension professional is to specifically address those functions or activities that are best suited to their blend of skills and experience (Figure 4). By so doing, they maximize the effectiveness and efficiency of any exchanges that occur.

Customers are frequently categorized into several groups—innovators, early adopters, early majority, late majority, and laggards (Rogers 1995). Innovators are the adventurers; early adopters are the opinion leaders. Both groups represent the small percentage of individuals (or organizations) that help move new ideas or technologies into the marketplace. The early majority group, the late majority group, and the laggard group represent those individuals (or organizations) that, respectively, procrastinate or deliberate, are skeptical or risk averse, or simply will not change until the world passes them by. Focusing knowledge exchange efforts on the innovators and early adopters can help build advocacy and facilitate flow of information, triggering action by the early and late majority.

Because of the diversity of customer groups, it is important to identify and cater to the "primary" customer as:

A. the person (or organization) who pays the bill for the product or service you are providing;
B. the person for whom the information or tool is specifically targeted; or
C. the person who represents a "go-between" responsible for helping facilitate the transfer process.

The identity of customer A would seem obvious; however, this is often uncertain when increasing amounts of operating dollars arise from external sources, but salaries are still paid by the home institution. This can create doubt regarding customer service focus, which is an increasing concern in government research institutions as budgets decline. Customer C reflects a "client continuum" in which basic researchers often rely on applied researchers to transform theoretical principles into practical tools, and applied researchers rely on extension professionals to translate and deliver information or tools to the "customer receptor team," the members of which represent the hub for communication flow within the organization. Failing to recognize the client continuum can derail the information flow.

Asking the Right Question

Historically, the research community has asked customers what information they want or what questions they would like answered rather than asking what their desired outcomes might be or what is preventing them from reaching these outcomes. A better approach is to ask the customer what they want a new product or service to do for them. This provides an open invitation to seek innovative solutions. The best opportunities spring from those desired outcomes that are important to customers, but are not yet satisfied by existing products or services. This opportunities-based approach improves on the gap-analysis approach, which considers only the difference between importance and satisfaction (Ulwick 2002). The process for soliciting this information involves a facilitator with the skills and insight to translate ambiguous dialogue into desired outcomes. In British Columbia, FORREX uses this approach to define strategic and annual goals as well as project-specific activities (Hollstedt 2003). FORREX partners are encouraged to accept these strategies and incorporate them into their work plans. Steering committees with key sector representatives define goals and advise the Board of Directors; experts

and customers participate in technical working groups to develop 5-year and annual work plans for program staff. As a result, programs can be evaluated not only on the basis of what was produced at what cost, but also on the basis of what outcomes were achieved as a direct result of the program activities. In this way, customers can clearly see whether expected outcomes are achieved and are able to comment on successes and areas for improvement. This approach can be used at both a strategic scale (corporate or program), as well as at a project-specific scale (solving one client's problem).

Preparing Participants to Excel

The researcher and the customer are both critical players in the knowledge exchange process. However, researchers or graduate students are rarely exposed to the principles and practice of knowledge exchange. Furthermore, most customers have limited "current" understanding of how or why a given piece of new knowledge or technology will simplify, add value to, or improve their job or operations. Although these are basic deficiencies, they are often neglected.

Researchers and graduate students are often not trained to communicate to a non-technical audience. They are trained to produce technical publications and to follow rigid protocols that focus on scientific rigour. Although important, these activities do not help researchers to understand the approach required to facilitate adoption and use of new information or technology. Thus, lack of understanding of what is needed and how to provide it becomes an obstacle to knowledge transfer. This, coupled with a rewards and incentive system (particularly in academic settings) that discourages serving non-technical customers, exacerbates the problem. This problem can be resolved by:

- instituting undergraduate or graduate course work, or professional development workshops, that teach best practices for knowledge exchange activities (Figure 2); and
- modifying reward programs for researchers.

Customers also need continuous education or training to remain current with knowledge advances that set new theoretical precedents, or that call for change in policies, practices, or ways of doing business. When people do not understand why they should change, it is very difficult to put new principles into practice. One solution is mid-career education that focuses on rejuvenating the theoretical foundations of ecological, economic, and social sciences for resource professionals (e.g., Forest Management Institute of BC; Gauthier *et al.* 2002). For example, the Silviculture Institute, which originated as a partnership between the U.S. Forest Service, Oregon State University, and the University of Washington, provides six 2-week, graduate-level education modules that present an ecosystem management approach to forest policy and practice. The program has been operating since 1977 and has served as a model for similar programs developed in British Columbia and Ontario. These programs:

- build understanding and confidence in resource professionals;
- develop advocates for integrating new knowledge into policies and practices; and
- foster strong relationships between researchers and resource managers that translate into valuable research and development opportunities.

Such programs also serve as excellent prerequisites to certification programs for resource professionals.

Breaking Down Intra-organizational Barriers

Intra-organizational barriers refer to an array of personal, cultural, and (or) technical deterrents to knowledge exchange (Table 1). Breaking down barriers to the adoption of new knowledge or technology involves developing an organizational learning culture and actively identifying and eliminating barriers to change.

Corporate learning is a function of corporate philosophy and culture, and enables organizations to anticipate, react, and respond to change, complexity, and uncertainty. Successful companies find ways to develop and advance knowledge for the future and leverage that knowledge into practice. A learning organization incorporates knowledge management into business processes. Corporate learning also creates processes, technologies, and collaboration opportunities that enhance learning from published and unpublished materials and the experience of individuals. However, to embrace the principles of corporate learning and put them into practice requires a substantial investment in human resources—an investment that should not be among the first items cut when reducing expenditures.

If this commitment to learning is achieved, barriers to adopting new technology can be minimized. If not, intra-organizational barriers become a significant impediment to innovation and production growth (Miller and Morris 1999; Szulanski and Winter 2002). The common barriers

TABLE 1. Common barriers to knowledge transfer (adapted from Szulanski 2000)

Barriers	Definitions
Casual ambiguity	Customer lacks understanding of why the new knowledge is important or how they might benefit from it, particularly if extrapolation is required
Unproven knowledge	Knowledge or technology has not been used elsewhere
Source lacks motivation	Researcher "has better things to do" than helping customer understand the utility and use of new knowledge or technology
Source perceived as unreliable	Researcher, marketer, or sales person is viewed as unreliable, whether real or perceived
Recipient lacks motivation	Customer is not interested in understanding (or developing a working knowledge) of the new approach or technology being proposed
Recipient lacks absorptive capacity	Customer lacks the educational or technical background (skills, shared language, experience, or up-to-date information) needed to understand the value of the knowledge, to re-create it, to apply it, or to exploit outside sources to learn about it
Recipient lacks retentive capacity	Customer is unwilling to change—the barriers to adopt new knowledge are significant and typically associated with casual ambiguity and absorptive capacity
Barren organizational context	Organizational culture is anti-innovation, anti-change, sticks to the status quo
Arduous relationship	Source–recipient incompatibility
Lack of spontaneity	Unwillingness to act quickly

to knowledge transfer (Table 1) are largely a function of four critical factors:

- personal relationships and trust,
- education,
- motivation, and
- organizational culture.

Assessing these factors can help to determine which intra-organizational issues require corrective action during the corporate knowledge transfer process. These factors can come into play at any one of the four phases associated with adoption and use of new knowledge—that is, during initiation, implementation, ramping-up, or integration into mainstream business practices. The barriers most likely to scuttle the process include casual ambiguity, source reliability, recipient absorptive capacity, and organizational culture (Table 1) (Szulanski and Winter 2002).

Benefits of Investment in Extension

Extension professionals who engage in knowledge exchange activities rarely promote themselves, or the institution of knowledge exchange. Consequently, the extension function often assumes an invisible role, although it is generally the array of knowledge exchange (or product-to-market) activities that are responsible for profiling research and development in the eye of the customer in the first place. This invisibility may lead to a lack of organizational support to adequately enable the extension function; however, when provided, such support guarantees that advances in research and development translate into organizational benefits.

The following benefits arise from knowledge exchange activities.

- Science activities are better aligned with corporate strategic goals and business objectives.
- Resources can be allocated to support new knowledge or innovations that enhance growth in production and competitive advantage for the business.
- Researchers (or institutions) receive positive feedback for their contributions and are more likely to receive additional funding.
- Resources are used more efficiently by identifying where technology transfer will suffice; this conserves research dollars for higher priority needs.
- Researchers and resource managers can focus on their primary function when extension professionals are engaged to fill the research-to-operations gap.

- Innovation results are more likely to be adopted and commercialized.
- Return on research investments is maximized through updated policies, improved practices, or product development and market expansion.
- Trust in information and information sources is increased.
- Resistance to adaptation through innovation is minimized.

The benefits provided by knowledge exchange activities serve as a strong justification for investment in extension. A number of effective extension models exist, both elaborate and simple. The key to successful extension is providing adequate investment. Effectively delivering the full array of knowledge exchange activities to the target audience (Figure 2) requires investment in the development and maintenance of the necessary infrastructure and intellectual capital. Lack of adequate investment allows competitors to capitalize on, and benefit from, research and development innovations—a scenario experienced in the United States during the early stages of the information technology revolution, and now being witnessed in Canada with the advent of a new bio-economy (Oliver 2000).

Summary

Information is not knowledge until it is known, and knowledge is not innovation until it is used. To capitalize on the benefits that can be derived from employing a knowledge exchange system, research managers need to take specific, proactive steps, including:

- Design and implement a knowledge exchange system that guarantees research and development activities are aligned with the projected needs of the customer.
- Ensure that each project team includes individuals responsible for addressing essential functions and activities in the research-to-operations continuum.
- Identify knowledge exchange functions and activities as priorities and provide enough resources to enable the effective, efficient operation of the system.
- Adopt or adapt the rewards and incentives protocols to advocate knowledge exchange activities that provide positive benefit for customers.
- Identify and work with the individual or team in the customer organization who is responsible for ensuring that knowledge is considered, tested, adopted, and used.

Information is not knowledge until it is known, and knowledge is not innovation until it is used.

- Establish a knowledge exchange culture by developing and supporting the principles and practices inherent in a learning organization.

An adequately funded, effectively managed innovation system, which fosters knowledge generation, knowledge exchange, and knowledge application in the forest sector, will help Canada remain a world leader in forest-based products and resource sustainability.

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